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DIE DESIGNING and ESTIMATING

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in order to add strength, finish, or protection to the edge.

Drawing dies cause radical changes in shape of a workpiece. This is done by drawing the metal over a continuous die edge into a die cavity. Flow of metal occurs throughout sizable areas. A drawing die is usually distinguished from a forming die in that side walls of the drawn piece are continuous.

Other Die Classification

Such dies as those intended primarily for stretch forming, extrusion, forging, swaging, heading, and embossing represent specialized production processes that individually call for a thorough discussion of entirely different conditions than are encountered in average shops.

These processes, and the tooling for them, are therefore considered beyond the scope of this text. Occasionally, a multiple operation die will be required to incorporate an extruding, swaging, or embossing operation but, usually, this minor application will not demand a thorough knowledge of the particular process. There will be times, too, when a separate operation in this group will be required as an intermediate step in the production of a sheet metal part.

Extrusion dies force the metal to flow ahead of the punch into a die cavity. The simplest application of extruding is the production of a pin or rivet-like projection on the surface of a workpiece.

Coining dies compress the metal, causing it to flow into depressions in the punch and die faces. This hardens and toughens the metal, as well as changing it dimensionally. Opposing tool surfaces can be dissimilar in detail.

Swaging dies also compress the metal, causing it to flow into depressions in the tool faces. Usually, when used in sheet metal work, swaging is the term applied to the operation that effects a radical change in dimension or physical properties, while *swells* refers to the production of surface detail and close-tolerance dimensions. Most engineers avoid entirely the use of the term *swaging* as applied to sheet metal work since it is the sole name of an entirely different and unique manufacturing process.

sheet metal work, the principle is used primarily to achieve horizontal detail rather than vertical detail. "Swedging" is occasionally used synonymously with "upsetting." This operation need not result in any appreciable reduction of volume. **Embossing** dies produce shallow surface details by displacement of the metal between two opposing mated tool surfaces having details in relief on the one and depressed on the other. The flow of metal is primarily stretching rather than compression.

Multiple-Operation Dies

Multiple-operation dies are often used to bring two or more cutting and forming operations together into one work cycle. However, each operation usually requires a separate punch-and-die unit, which is subject to the same general considerations as a one-operation die that performs the same function. The principal types of multiple-operation dies are the compound, combination, and progressive.

Compound and combination dies are designed so that all operations are performed on the workpiece within a single work cycle, without movement of the workpiece. In such dies, tools for all operations are grouped about a common vertical or axial centerline. The operations are performed either simultaneously or successively. The terms "compound" and "combination" are used synonymously by some engineers, although the following usages are preferred:

Compound dies combine two or more cutting operations, such as blanking and piercing. These are usually single-action dies, with all operations being done with one ram stroke. Punch lengths may be staggered in order to break up the total work load.

Combination dies combine cutting with forming or drawing operations. These are usually multiple-action dies, with one operation succeeding another. This is achieved entirely within the die assembly by use of cam-actuated punch and die members, or by designing the die for use on a double-action press which has two independent rams or slides, one moving inside of another.

Progressive dies are distinctive in that the workpiece travels from one "station" to another with separate operations be-